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Over and Under Pressurizing of Ship Tanks during Ballasting and deballasting - Hull Damage

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ABSTRACT

A safety relief hole of 6 to 8mm diameter is generally provided in Air-pipes to prevent accidental over and under-pressurizing of ship tanks during ballasting and deballasting. This paper investigates the pressure rise and drop inside the tank assuming the air-pipe to be closed. A practical method based on computational fluid dynamics has been presented to find out the maximum pressure rise or drop. A parametric study, based on varying relief hole diameter, has been carried out. The investigation brings to prospective the extent of pressure rise or drop, and hence the damages that can occur due to poor operation of the Air-pipes during ballasting and deballasting and a need for automated opening and closing of the Air-pipes for a safer ship.

KEY WORDS: Air-pipe, Pressure relief hole, CFD, Ballasting

NOMENCLATURE

a_0 = Common Acceleration Parameter
h_p = Vertical distance from the load point to the top of the air pipe
h_s = Vertical distance from the load point to the top of the tank or hatchway.
v = Maximum Service speed in knots

INTRODUCTION

There have been many incidents of hull damage due to over and under-pressurizing of ship tanks during ballasting and deballasting Under-dimensioned or faulty Air-pipes, choked pressure/vacuum (P/V) valve have resulted in these incidences. . Air-pipes are normally provided with valves/lid to protect the tanks from green water during voyages.

One of the central cargo tanks, of an Oil Tanker (Det Norske Veritas, 1999) burst during cargo loading, causing the central part of the deck to lift approximately 8 inches. The probable cause was inoperative P/V-valve. During another incident on a Bulk Carrier (Det Norske Veritas, 1999), the internal structure of the topside wing tank was found buckled and detached from the steel structure. The probable cause was found to be over-pressurizing of the tank, which is normally designed for a water head of approximately 2.5 m.

The tank structure can also get damaged during deballasting operation. Due to continue pumping out, a very low pressure can develop in the tank, leading to bending of the tank bulkheads inward. The air-pipes of the tanks are generally provided with a safety relief hole of 6 mm to 8 mm diameter to prevent such casualties. But 6 mm to 8 mm may be some times under-dimensioned.

This paper presents a Computational Fluid Dynamics based method to find out the maximum pressure drop or rise in the tank during deballasting and ballasting operation respectively. The 3d tank, with the Air-pipe and the relief hole, has been modeled and the flow field has been simulated using a general-purpose CFD code, Ansys CFX-11.0. A parametric study, based on varying relief hole diameter, has been carried out to find out, the variation of, the pressure rise or drop in the tank during ballasting and deballasting. The pressure rise or drop inside the tank can exceed the design load of the tank wall, leading to its damage. The study was carried out to find a safer dimension of the relief hole for an inland water General Cargo Vessel.

NUMERICAL METHODS

The Finite Volume commercial CFD code, Ansys CFX-11.0, a cell centered based unstructured solver was used to carry out the computations. The numerical approach involves discretizing the spatial domain into finite control volumes using a mesh. The governing equations of mass and momentum are integrated over each control volume, such that the relevant quantity (mass, momentum, energy, etc.) is conserved in a discrete sense for each control volume.

Advection term has been discretized using High Resolution scheme and the transient term has been discretized using second order upwind scheme. The discretized equations were solved using Algebraic Multigrid method. The hydrodynamic equations were solved as a single system. This solution approach used a fully implicit discretization of the equations at any given time step.